ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

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ACOUSTICS AND NOISE CONTROL IN CANADA

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CONTRIBUTIONS

Articles in English or French are welcome. They should be addressed to a regional correspondent or to a member of the editorial board.

SUBSCRIPTIONS

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(continued on inside back cover)

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CONTRIBUTION

Vous êtes invités à faire parvenir des articles en anglais ou en français. Prière de les adresser à un correspondant régional ou à un membre de la rédaction.

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(suite au recto de la couverture inférieure)

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Notice Board

Institute of Acoustics Spring Conference '77

The Institutes Spring Conference and Exhibition is to be held at the University of Bath, Claverton Down, Bath On April 4-6, 1977. The topics covered by the conference will include:

Ultrasonic Studies of Solids and Liquids
Acoustic Properties of Materials
High Intensity Sound and Ultrasound
Industrial Uses of Noise and Vibration
Neighbourhood Noise

An important feature of the Conference will be a specialist symposium which will present and discuss work and progress on Underwater Acoustic Studies of Sediments.

An exhibition of acoustics and ultrasonics will also form part of the Conference activities. An individual or organization wishing to take part in the exhibition or wishing further details on the conference should write to

The Secretary
Institute of Acoustics
47 Belgrave Square
London SW1X 8QX

C.A.P. Symposium on Ultrasonics

Professor D. Cheeke and his associates at the Groupe de Recherche sur Les Semiconducteurs et les Dielectriques of the University de Sherbrooke organized the meeting which was held on October 29 and 30. The programme contained (i) quantum effects in solids, (ii) surface waves, generation and detection, (iii) surface wave devices, (iv) industrial applications of ultrasonics, (v) imaging and holography in relation to medical diagnosis.

About fifty people attended and about fifteen papers were presented at the meeting. A tour of the GRSO labs was included. Further information about the meeting can be obtained from H.W. Jones, University of Calgary.

POSITION WANTED

Acoustical Engineer, currently Head of the Acoustical Laboratory, National Institute of Industrial Technology, Argentina.

Bachelor's degree in Electronic Engineering (1956), M.Sc. in Acoustics (1969).

Considerable teaching experience at the University of Buenos Aires and the National Technical University. Numerous papers on architectural acoustics, sound measurements, hearing protection and acoustical materials. Has spent periods in Britain (at Imperial College, ISVR, Building Research Station) under British Council Scholarship; in Texas (Callier Center) under Fulbright Scholarship; and in Germany and again in Britain under UN auspices.

Member ASA, BAS and currently President of Argentinian Acoustical Society. Fluent in English, French and Spanish.

Referees: Dr. George Moushegian, Callier Institute, 1966 Inwood Rd., Dallas, Texas. 75235; Dr. Daryl May, Ontario Ministry of Transportation & Communications, phone (416) 248-3771.

Please write for full resume: Alberto Behar, Avenida La Plata 790, Buenos Aires 1235, Argentina.

MINUTES OF CAA BUSINESS MEETING

6th October 1976

Held in Faculty Club, University of British Columbia, Vancouver.

R.J. Donato, Physics Division, National Research Council,
Ottawa, Ontario, K1A OS1.

The President, Hugh Jones, called the meeting to order at 20:00 hrs with 27 members present. As no items had been raised by the membership in response to the invitation in a recent Newsletter he suggested the agenda be: -

Minutes of last annual meeting and business arising therefrom, including

a) Foreign consultants in Canada
b) International INCE
c) Legal status of CAA and incorporation
d) Treasurer's Report
e) Editor's Report
f) Any other business
g) Election of Officers.

A motion to accept the agenda was proposed by J. Manuel and seconded by J. Foreman.

FOREIGN CONSULTANTS IN CANADA

The President read to the members the text of the letter he had sent to the Hon. R. Andras who was at that time the Minister of Manpower and Immigration. In summary, the letter drew the Minister's attention to the difficulties of Canadian consulting acoustical engineers faced with foreign competition for work being contracted by various government departments in Canada. The competition was unequal in that in particular US consultants have to satisfy less stringent requirements to obtain work in Canada than Canadians in the U.S. Further, standards which it is hoped will be accepted and used in Canada are not always required in the U.S.

The reply from Mr. Andras stated that it is the policy of the Federal Government that foreign workers will not be admitted for temporary employment if a qualified Canadian or a permanent resident is available and willing to take the employment. The responsibility to implement this policy rests with Canada Manpower Centres. Sometimes special circumstances exist when this general rule must be broken, and until recently specialists could be transferred into Canada by their employers. As many engineers were being admitted under this provision the manpower centres are now required to ascertain the availability of qualified Canadians, and acoustical engineers and professional associations would be consulted. The references to noise abatement standards had been forwarded to the Ministers of Public Works and the Environment.

The President added that a copy of the letter would be available for anyone presenting a specific complaint on this matter to his local Canadian Manpower Centre.

J. Manuel proposed a copy of the letter be sent to engineering bodies in Canada. K. Harford seconded this and the motion was carried. D. Whicker added that a similar procedure to equalize competition had been tried with B.C. engineers but the reluctance of some members who anticipated difficulty in introducing their own consultants into Canada had prevented its acceptance.

INTERNATIONAL INSTITUTE OF NOISE CONTROL ENGINEERING (I/INCE)

The President had thanked Dr. Lang for his invitation to join I/INCE and had asked him for

1) the financial implications of joining I/INCE
2) details of the membership
3) a short history of I/INCE
4) names of present officers

While answers had been received to the questions it was felt that a decision on whether or not to join might be more appropriate after our legal status and proposed incorporation had been acted upon one way or the other. J. Manuel proposed that such a decision be deferred sine die and T. Siddon, whilst seconding the motion, asked about the advantages and costs of joining. The President replied that I/INCE assists the pursuit of Noise Control Engineering, has its own publication, holds international meetings which are arranged not to conflict with other international, national and local society meetings, and contributes to the development of international standards. The cost is 350 Swiss francs per year and there are at present 9 societies associated with I/INCE. T. Siddon wondered whether I/INCE would exclude US from other bodies, ICAO for example, but the President reminded him we were already affiliated with ICAO. The motion was moved and carried.

LEGAL STATUS AND INCORPORATION

The Dean of Law at the University of Calgary, at the request of H. Jones had approached the Ministry of Consumer Affairs to see whether our name was suitable for incorporation. The Ministry's first response was negative in that they felt our name had some resemblance to existing companies' names. However, a more forceful presentation caused them to reconsider and to approve our name.

A set of by-laws, necessary for incorporation, and based on those used at the Industrial Research Centre at Windsor, had been prepared and were presented to the members at the meeting. There were some errors in the by-laws and these were corrected. The President said we could go through the by-laws item by item but the really important question we must decide was whether or not to incorporate. That being decided the by-law document could be used as a provisional document and after incorporation had occured changes could be made. If the document were found to be reasonable and just we could accept it provisionally; if not we could discuss any points raised.

D. May thought we should have the discussion if it did not take too long, but the President said no discussion was relevant until the decision to incorporate had been taken. T. Siddon moved the acceptance of the by-laws in principle, and recommended the new President refine them. The President asked if anyone would propose we incorporate, and J. Manuel proposed, D. Whicker seconding, such a motion.

D. Whicker asked D. McKay if he would like to comment on the Ministry of the Environment's future policy on the publication of the Newsletter. D. McKay replied that the 650 copies would be published free by MOE but of course the situation could change. If it did it would be easier for the Association to publish on its own if it were incorporated. And if MOE asked the CAA to shoulder some of the cost it would be easier to deal with an incorporated body.

A. Lees asked about the advantages of incorporation. The President replied that there would then be limited liability to officers of the Association, the CAA would be able to enter into contracts with government, payments made would be eligible for income tax rebate, and from the Ministry of Consumer Affairs point of view there would be a set of identifiable by-laws.

E. Bolstad reminded the members that discussions on these lines had been going on over the last four years. The strongest opposition had come from the oldest members who feared that both the informality of the Association would be lost and its effectiveness reduced by such a move as incorporation. The President felt incorporation to be necessary. He foresaw the time when the Association might have to act as a pressure group, and the influence of the Association would increase upon incorporation. The vote was taken upon the motion that the CAA should be incorporated, and was passed unanimously.

BY LAWS & OBJECTIVES

J. Manuel asked whether the by-laws were to come into force at the next general meeting and if there would be a year for further consideration. H. Jones felt they would be an interim set for a year and that they could then be reconsidered. W. Bradley asked whether the meeting authorizes the executive to approach the government with the by-laws and ask to be incorporated. In that case there will not be a year for further consideration. In one year we would be incorporated, with a set of by-laws, and these by-laws could be then subject to amendment. The President replied that the provisional by-laws plus any advice recommended at this meeting could lead to the first set of by-laws presented upon the application to incorporate.

D. May recommended that an opportunity be made for input and the President reiterated that this could take place in the subsequent modifications after incorporation. T. Siddon proposed the by-laws be adopted in principle and that the incoming executive be given power to negotiate subject to legal advice. This was seconded by J. Welch. D. Whicker proposed an amendment ot the by-laws. That Item 4 which read 'A charge may be made for membership and shall be levied equally upon all members' should have substituted 'shall' for 'may' and that the words 'as recommended by the executive' be inserted after 'membership'. E. Bolstad seconded this.

J. Manuel proposed an amendment to the amendment in that merely the word 'may' he replaced by 'shall', but he failed to attract a seconder. J. Welch felt the amendment to be out of order as the motion under discussion was the action to be taken by the executive. J. Foreman agreed and suggested that the amendment should be discussed separately under advice to the executive. Accordingly the President asked the mover of the amendment whether the amendment could be presented later. This was agreeable to the seconder. T. Siddon drew attention to the wording of his motion, especially to the words 'in principle', and felt that the executive could receive suggestions on how to act but felt that this was matter to be discussed after his motion has been voted on. W. Bradley proposed an amendment that incoming officers be regarded as directors (Secretary's note: the proposed by-laws specifically mention directors of the CAA as distinct from the executive. The directors manage the property and business of the incorporated body, and are eligible for re-election each year.) The President considered the amendment out of order. J. Foreman disagreed and drew attention to the by-law which specifically mentioned that provisional directors were to be named in the letters patent of the incorporation. T. Siddon changed the wording of his original motion from 'executive' 'to provisional officers or directors'. J. Foreman seconded. T. Siddon although proposing the motion felt confused in that there were no provisional directors at the moment. D. McKay added some clarification by explaining that under the Canadian Corporations Act an incorporated body must have at least three directors and these were defined under the act. E. Bolstad also explained that often provisional directors are attorneys who eventually turn over their directorship. Finally T. Siddon again modified the motion to 'the by-laws be accepted in principle and that the incoming executive be given powers to act as directors and negotiate incorporation of the CAA'. J. Welch seconded. The motion was carried.

ADVICE TO THE EXECUTIVE RE BY-LAWS

D. Whicker proposed the motion on by-law 4 that 'a charge shall be made' .... rather than 'a charge may be made .....' (see previous discussion). The motion was seconded by J. Manuel. G. Faulkner asked why 'shall' was important and D. Whicker answered that charges will be incurred, possibly with regard to the Newsletter, and that as an incorporated body we should have funds; hence a membership fee was necessary. W. Bradley agreed. D. Quirt felt that the decision to charge a fee should state what that fee should be. J. Welch felt that the fee should be approved annually. The President felt that this situation was covered in Item 34 (Secretary's note: Item 34 states inter alia that the by-laws may be repealed or amended by a further by-law sanctioned at a general meeting). The motion was carried with some dissension.

E. Bolstad raised the point that with a fee structure the question of qualifications for membership arises. There would be more elaborate bookkeeping and an outlawing of people who haven't paid their fees. He hoped everybody realised that the whole modus operandi would be altered. D. McKay felt the by-laws were previously flexible, whereas now with fees chargeable, the flexibility was reduced. The President reminded the members that in voting for the acceptance of the by-laws in principle the meeting had accepted Item 34, which allowed for discretion. J. Manuel added that this meeting was only offering advice, and that the executive would be looking at the whole financial situation, including the fees added by the annual meetings. J. Foreman proposed that the incoming officers, namely the president, past president, executive secretary, editor, treasurer, convenors of the next and past annual meetings form a provisional board of directors, and that one other member-at-large be added. W. Bradley seconded and the motion was carried.

TREASURER'S REPORT

E. Bolstad reported that on October 9th, 1975 we had $36.25 in hand. With a profit of $270.00 arising from registrations at the 1975 meeting and allowing for printing, stationary charges etc. the 1975 year end balance was $254.29. This year the consultants directory had realised $390.00 and the profit arising from this year's meeting was expected to be about $544. He remarked that these were funds with no allocation or budget, and that sooner or later we would have to have a budget.

J. Manuel moved acceptance of the budget and D. Merritt seconded: - carried.

EDITOR'S REPORT

G. Faulkner felt any changes to editorial policy could be deferred until after incorporation. The input from the annual general meeting (technical and business) provides material for several issues of subsequent Newsletters, but it is not a certain supply. The regional correspondents had been difficult to use effectively, and material sent from them is not frequent. In fact, in some cases even their status is unknown.

J. Foreman outlined the history of the regional correspondents. He felt now that the Editor should appoint his own regional correspondents as the present ones had been approached several years ago by another executive. D. May agreed and he pointed out that some regional correspondents might not wish to continue. J. Manuel moved that the editor's report be accepted and that the editor approach the regional correspondents to confirm their viability. D. May wondered whether we need to be that formal, and the President confirmed that the Editor already has the necessary powers. D. McKay seconded the motion. D. Whicker proposed an amendment that the meeting accept the Editor's report and the Editor select his own correspondents. J. Manuel then withdrew the second part of his motion and moved simply that the editor's report be accepted. This was seconded by J. Welch and the motion was carried.

L. Russell, speaking as a regional correspondent, said that one of the problems was that no one tells the correspondents what is needed. Some news items by-pass the correspondents and are sent directly to the Editor. He felt that some clarification was needed and the Editor should tell the correspondents what was required. T. Siddon felt that a close relationship does not exist in some areas. Were more news items wanted? G. Faulkner, the Editor, replied that L. Russell was a good correspondent, and confessed he did not know the purpose of the original correspondents. He appreciated T. Siddon's point and felt that the Editor will need more help if the organization gets larger. F. Toole felt the Editor should organize his own system. E. Bolstad proposed a vote of thanks to the Editor.

OTHER BUSINESS

J. Foreman cautioned incoming officers to look closely at eligibility for membership. The by-laws state in Item 3 that 'membership .... be available to all persons interested in furthering the objectives of the association .....' He said there are no qualifications for membership. T. Siddon said the point was covered in the same item (Item 3) which goes on ' ..... whose applications ..... have received the approval of the board of directors'. F. Toole felt applications could be supported by referees who could veto the directors (or vice versa).

ELECTION OF OFFICERS

J. Foreman gave a report of his nominating committee. He had suggested such a committee be formed of the immediate past president and Association members selected at his discretion, to introduce a slate of candidates to be presented at the Annual General Meeting. Members should also be prepared to submit additional nominees from the floor.

The names the committee proposed were.

President:	C.W. Bradley	(3)
Past President:	H.W. Jones	(3)
Secretary:	C.W. Sherry	(2)
Editor:	G. Faulkner	(2)
Treasurer:	E.H. Bolstad	(1)

The numbers in parentheses are recommended periods of service for the new candidates. Thereafter, while the membership may have the opportunity to change officers the Nominating Committee may recommend extension for up to say four years.

As there were no nominations from the floor the above list was voted on.

President: Proposed H. Jones, seconded J. Manuel: carried
Secretary: Proposed H. Jones, seconded J. Manuel: carried
Editor: Proposed D. Whicker, seconded F. Toole: carried
Treasurer: Proposed M. Merritt, seconded G. Faulkner: carried
Member-at-large: D. Whicker proposed J. Manuel and J. Hemmingway seconded: carried

E. Bolstad proposed the next meeting be held in Ottawa. This was seconded by G. Faulkner and carried.

C.W. Bradley proposed a vote of thanks to the retiring President and Secretary.

A. Soom proposed the meeting be adjourned and M. Merritt seconded: carried.

Suggested Provisional By-Laws of the Canadian Acoustical Association

OBJECTIVES OF THE ASSOCIATION

1. The Association has as its objectives the following:

(a) The fostering of high standard of scientific, engineering and medical endeavour in all the branches of acoustics in Canada

(b) The encouraging of liaison between individuals, groups, governments, and other organisations engaged in activities relating to acoustics and

(c) the dissemination of knowledge relating to acoustics and its applications.

It is not the purpose of the Association to seek to establish the professional status of its members, believing this is the concern of other organisations.

It may, however, give special recognition or awards to individuals who, in the opinion of the board of directors of the Association, are particularly meritorious.

In the following the word "Corporation" is deemed to refer to the Association.

CORPORATE SEAL

2. The name of the corporation shall be the Canadian Acoustical Association and the seal of the corporation shall be in such form as shown below :

CONDITIONS OF MEMBERSHIP

3. Membership in the corporation shall be available to all persons interested in furthering the objectives of the corporation and whose applications for admission as members have received the approval of the board of directors.

4. A charge shall be made for membership and shall be levied equally upon all members.

5. Any member may withdraw from the corporation by delivering to the corporation a written resignation and lodging a copy of the same with the secretary of the corporation.

6. Any member may be required to resign by a vote of three-quarters of the members at an annual meeting.

HEAD OFFICE

7. The head office of the corporation shall be located at the City of , in the Regional Municipality of and Province of , Canada, at the place therein where the business of the corporation may from time to time be carried on.

8. The corporation may establish such other offices and agencies elsewhere within Canada as the board of directors may deem expedient by resolution.

BOARD OF DIRECTORS

9. The property and business of the corporation shall be managed by a board of eight directors of whom a majority shall constitute a quorum. The board of directors may on literature of the corporation be designated as a board of governors.

10. Directors shall be eligible for re-election at the annual meeting of members for terms of service which do not exceed four years in total.

11. The office of director shall be automatically vacated

(a) if a director shall resign his office by delivering a written resignation to the secretary of the corporation,

(b) if he is found to be a lunatic or becomes of unsound mind,

(c) if he becomes bankrupt or suspends payment or compounds with his creditors,

(d) if at the annual meeting or special general meeting of members a resolution is passed by three-quarters of the members present at the meeting that he be removed from office.

(e) on death;

provided that if any vacancy shall occur for any reason in this paragraph contained, the directors may by resolution fill the vacancy with a person in good standing on the books of the corporation as a member.

12. Meetings of the board of directors may be held at any time and place to be determined by the directors provided that five days notice of such meeting shall be sent in writing to each director. No formal notice shall be necessary if all directors are present at the meeting or waive notice thereof in writing.

13. Directors, as such, shall not receive any stated remuneration for their services.

14. A retiring director shall remain in office until the dissolution or adjournment of the meeting at which his successor is elected. A director shall hold office until the next annual meeting of members following his election or appointment.

15. The directors may exercise all such powers of the corporation as are not by the Canada Corporations Act or by these by-laws required to be exercised by the members at general meetings.

16. Upon election at the first annual meeting of members, the board of directors then elected shall replace the provisional directors named in the letters patent of the corporation.

17. A majority of the directors shall have power to authorize expenditures on behalf of the corporation from time to time and may delegate by resolution to an officer or officers of the corporation the right to employ and pay salaries to employees. The directors shall have the power to make expenditures for the purpose of furthering the objects of the corporation. The directors shall have the power to enter into a trust arrangement with a trust company for the purpose of creating a trust fund.

18. The board of directors shall take such steps as they may deem requisite to enable the corporation to receive donations and benefits for the purpose of furthering the objects of the corporation.

OFFICERS

19. The officers of the corporation shall be a president, immediate past president, executive secretary, editor, treasurer, the conveners of the next and last annual meeting of the Association and such other officers as the board of directors may by by-law determine. The offices of executive secretary and treasurer may not be held by the same person.

20. The president and other officers, apart from the immediate past president and the conveners of the next and last annual meeting, shall be elected at the annual meeting of members.

21. There may be such honorary officer or officers as the board of directors may from time to time consider advisable and they shall hold office for such period of time as may be prescribed by the board.

22. The board may appoint such agents and engage such employees as it shall deem necessary from time to time and such persons shall have such authority and shall perform such duties as shall be prescribed by the board at the time of such appointment.

23. The officers of the corporation shall hold office for one year and/or until their successors are elected or appointed in their stead.

DUTIES OF OFFICERS

24. The president shall be the chief executive officer of the corporation. He shall preside at all meetings of the corporation and of the board of directors. He shall have the general and active management of the business of the corporation. He shall see that all orders and resolutions of the board are carried into effect and he with the executive secretary or other officer appointed by the board for the purpose shall sign all by-laws and other documents requiring the signatures of the officers of the corporation.

25. The past president shall, in the absence or disability of the president, perform the duties and exercise the powers of the president and shall perform such other duties as shall from time to time be imposed upon him by the board. He will prepare a list of candidates for presentation to the Annual General Meeting for consideration by that meeting prior to the conducting of elections.

26. The treasurer shall have the custody of the corporate funds and securities and shall keep full and accurate accounts of receipts and disbursements in books belonging to the corporation and shall deposit all

moneys and other valuable effects in the name and to the credit of the corporation and in such depositories as may be designated by the board of directors from time to time. He shall disburse the funds of the corporation as may be ordered by the board, taking proper vouchers for such disbursements, and shall render to the president and directors at the regular meeting of the board, or whenever they may require it, an account of all his transactions as treasurer and of the financial position of the corporation. He shall also perform such other duties as may from time to time be determined by the board.

27. The executive secretary shall attend all sessions of the board and all meetings of the members and act as clerk thereof and record all votes and minutes of all proceedings in the books to be kept for that purpose. When the business of the Association is conducted by the directors by mail he will similarly act as clerk and keep records. He shall give or cause to be given notice of all meetings of the members and of the board of directors, and shall perform such other duties as may be prescribed by the board of directors or president, under whose supervision he shall be. He shall be custodian of the seal of the corporation, which he shall deliver only when authorized by a resolution of the board to do so and to such person or persons as may be named in the resolution.

EXECUTIVE COMMITTEE

28. The board of directors may from time to time elect from among its number an executive committee consisting of such number of members, not less than two, as the board of directors may by resolution determine. Each member of the executive committee shall serve during the pleasure of the board and, in any event, only so long as he shall be a director. The board of directors may fill vacancies in the executive committee by election from among its number. Whenever a vacancy shall exist in the executive committee, the remaining members may exercise all its power so long as a quorum remains in office.

29. During the intervals between the meetings of the board of directors the executive committee shall possess and may exercise (subject to any regulations which the directors may from time to time impose) all the powers of the board of directors in the management and direction of the affairs of the company (save and except only such acts as must by law be performed by the directors themselves) in such manner as the executive committee shall deem best for the interests of the corporation in all cases in which specific directions shall not have been given by the board of directors.

30. Subject to any regulations imposed from time to time by the board of directors, the executive committee shall have power to fix its quorum at not less than a majority of its members and may fix its own rules of procedure from time to time.

31. Meetings of the executive committee may be held at the head office of the company or at any other place in or outside Canada. The executive committee shall keep minutes of its meetings in which shall be recorded all action taken by it, which minutes shall be submitted as soon as practicable to the board of directors.

MEETINGS

32. The annual meeting of the members of the corporation shall be

held at the head office of the corporation or elsewhere in Canada as the board of directors may designate. At such meeting the members shall elect a board of directors and shall receive a report of the directors.

33. Twentyeight days prior written notice shall be given to each member of any annual or special general meeting of members. Twelve members present in person at the meeting shall constitute a quorum. Each member present at a meeting shall have the right to exercise one vote.

AMENDMENT OF BY-LAWS

34. The by-laws of the corporation may be repealed or amended by by-law enacted by a majority of the directors at a meeting of the board of directors and sanctioned by an affirmative vote of at least two-thirds of the members at a general meeting duly called for the purpose of considering the said by-law, provided that the enactment, repeal or amendment of such by-law shall not be enforced or acted upon until the approval of the Minister of Consumer and Corporate Affairs has been obtained. Such amendments shall be presented to the next annual meeting of the Association for its consideration.

35. A member may appoint as his proxy any other member to vote at any annual or special general meeting provided such appointment is made in writing and the secretary of the Association is so informed.

36. At all meetings of members of the corporation every question shall be determined by a majority of the votes cast at the meeting unless otherwise specifically provided by the Canada Corporations Act or by these by-laws.

37. The financial year of the corporation shall be the year starting on 1st September.

AUDITORS

38. The members shall at each annual meeting appoint an auditor to audit the accounts of the corporation to hold office until the next annual meeting provided that the directors may fill any casual vacancy in the office of auditor. The remuneration, if any, of the auditor shall be fixed by the board of directors.

SIGNATURE AND CERTIFICATION OF DOCUMENTS

39. Contracts, documents or any instruments in writing requiring the signature of the corporation, shall be signed by any two of the president, immediate past president, secretary or treasurer and all contracts, documents and instruments in writing so signed shall be binding upon the corporation without any further authorization or formality. The directors shall have power from time to time by by-law to appoint an officer or officers on behalf of the corporation either to sign contracts, documents and instruments in writing generally or to sign specific contracts, documents and instruments in writing. The seal of the corporation when required may be affixed to contracts, documents and instruments in writing signed as aforesaid or by any officer or officers appointed by resolution of the board of directors.

RULES AND REGULATIONS

40. The board of directors may prescribe such rules and regulations

not inconsistent with these by-laws relating to the management and operation of the corporation as they deem expedient, provided that such rules and regulations shall have force and effect only until the next annual meeting of the members of the corporation when they shall be confirmed, and in default of confirmation at such annual meeting of members shall at and from that time cease to have force and effect.

41. In these by-laws the singular shall include the plural and the plural the singular; the masculine shall include the feminine.

IN WITNESS WHEREOF we have hereunto set our hands at the City of , this day of 197

Applicants

THE ASSESSMENT OF ANNOYANCE DUE TO TRAIN NOISE

BY J.R. HEMINGWAY

Noise Pollution Control Section, Pollution Control Branch
Ministry of the Environment, Ontaio.

1. INTRODUCTION

In our modern society many people are obliged to live in areas subjected to high noise levels due to the major transportation sources - aircraft, traffic and trains. Much research has been performed in an effort to obtain annoyance assessment scales for aircraft (1) and traffic noise (2) and even a unified assessment scale which applies for several noise sources (3). Relatively few investigations have been orientated towards the specific problem of train noise.

In the past the sound of steam locomotives was thought to be a relatively acceptable, even enjoyable sound. Unfortunately the passing of the steam locomotive has left us with the diesel locomotive which does not possess the romantic image of the old steam locomotives. It is still thought however, that train noise is one of the more acceptable noises, many people being willing (or perhaps obliged) to live close to railway tracks. This opinion is reinforced by the feeling that these people do not complain about train noise. However, many complaints are received by the relevant authorities. A second point is that actual complaints are not thought to be a satisfactory measure of annoyance. Many people may be annoyed but few complain. The work which has been performed on train noise annoyance (4,5,6, all summarized in 7) is of an international nature, studies being undertaken in England, France and Japan. To the authors knowledge no major attempt has been made to correlate annoyance with train noise in Canada. It is often remarked that annoyance is a function of national conditions and traits making the need for local research an important one.

To fulfill the need for an assessment scale for determination of annoyance due to train noise a project was instituted by this Ministry. The work was performed by five Seneca College students under the supervision of the Noise Pollution Control Section of the Ministry of the Environment and financed throught the Experience '75 scheme.

The objectives of the project, as relevant to this paper, were to perform noise measurements at various sites close to railway tracks in the Metro Toronto area; to analyze these noise measurements on a day, evening and night basis to yield statistical parameters such as L_{90}, L_{50}, L_{10}, L_1 , $L_{0.1}$, L_{eq} (both total site L_{eq} and train alone L_{eq}) and also train parameters such as audible train duration; to perform interviews with people living close to the monitoring locations; to correlate the noise descriptors with the sociological survey results; to choose the most appropriate noise descriptor and finally to construct a train noise annoyance rating scale based on this noise descriptor.

The overall objectives of the project were wide and not confined to the investigation of train noise annoyance. Much socio-economic data were obtained as well as information on the assessment of other noise sources. This report will be concerned only with the train noise aspects of the project. The remainder of the project contains a wealth of information to be reported at a later date.

2. SITE SELECTION

Initially site selection was performed by studying maps to find suitable streets running close to railway tracks (both Canadian National Railways and Canadian Pacific Railways) and avoiding other major sources such as industry and freeways. However, as it was wished to provide a variety of noise backgrounds to the train noise, areas were also chosen with high expected traffic flows-in downtown areas-and those with low expected traffic flows-in suburban areas. The noise background variation was also provided by selecting sites not only directly abutting the railway tracks but also shielded by one or more rows of housing.

It was also felt advisable to vary the class of the neighbourhood to achieve some variety in the income levels of the survey respondents. It was also thought necessary to provide a range of train movements past particular sites.

Final site assessment was performed by a site visit to eliminate sites subjected to temporary noise (construction, road repairs) and to select actual noise monitoring locations (usually trees, telephone or hydro poles). In all, some 19 sites were selected in this way. Adequate success was achieved in randomizing the parameters of: number of train movements, distance from track, noise background to trains and type of neighbourhood despite relatively low number of sites selected.

3. NOISE MONITORING & ANALYSIS

Noise monitoring was performed at each of the 19 selected sites. Portable battery operated analog monitors were used, these being constructed originally for the London-Woodstock attitudinal survey (8), recently modified and rebuilt by the Noise Pollution Control Section.

The sound was detected by a G.R. 1 inch ceramic microphone amplified and passed unweighted to a Uher 4200 Report Stereo tape recorder. The sound sample was recorded on both channels, one channel recording low sound levels, the second high sound levels. This technique was used to extend the effective dynamic range of the tape recorder to some 70 dBA. Calibration was by means of a G.R. 1562 A sound level calibrator producing 114 dB at 1 KHz.

Each site was monitored at least twice, once with a timer unit (which records for 10 seconds every 2 ½ minutes) and a trip level unit (which records all sounds above a preset level). This technique ensured that all sounds occurring on each site were recorded, those repeated very often by the timer unit, and those of a transient nature by the trip level unit.

The tapes were analyzed by playing back on a Uher 4200 Report Stereo tape recorder and passing in two channels to a Gating Circuit which put the high and low sound level recordings back into a single output. A-weighting was also performed by the Gating Circuit. The signal from the Gating Circuit was then passed to a B & K 2305 level recorder and analyzed into 5 dB bands by a B & K 4420 statistical distribution analyzer. The analysis was analyzed further on a Wang programable calculator to give the cumulative statistical distribution, L_{eq} and σ.

Tapes from the timer unit were analyzed on a day, evening and night basis. Trip level tapes were treated slightly differently. First the whole noise sample on the tape (composed of all events above the preset level) was analyzed and secondly the train noise alone was analyzed. Accurate day, evening and night information could not be recovered from the trip level tapes as short duration events could only be assumed to be equally spread over twenty-four hours. In this report little emphasis will be given to differences between day, evening and night levels, and the train noise results considered on a 24 hour basis only.

After analysis the results for each tape were drawn out on statistical distribution paper and parameters such as L_{90}, L_{50}, L_{10}, L_1, $L_{0.1}$, L_{eq} (total), L_{eq} (trains only), L_{eq} (trains only spread over 24 hours) and train duration per 24 hours were derived.

Successful monitoring and analysis of noise recordings was performed for a total of 17 sites.

4. SOCIOLOGICAL SURVEY

The sociological portion of this project was based on a questionnaire constructed and pretested by Dr. Fred Hall and Dr. Martin Taylor of the Civil Engineering and Geography Departments, McMaster University. The questionnaire was examined carefully by the Noise Pollution Control Section to check on the acoustical background and also by Dr. Cesare Ruscone, lecturer in social research techniques at Seneca College. A few minor alterations were incorporated as a result of this examination.

The questionnaire was broad based, containing questions concerned with overall neighbourhood rating as well as specific noise source questions. Questions were included to assess activity and sleep interference and also annoyance assessment of particular noise sources. It is the latter question which is of primary importance to this paper. The stages of questioning related to the assessment of a noise source were as follows:

(a) What noises are clearly audible to you in this neighbourhood?
(b) How would you rate each of the noises you've mentioned?

The respondent was then handed a card with the following intensity scale:

1. Extremely agreeable
2. Considerably agreeable
3. Moderately agreeable
4. Slightly agreeable
5. Neutral
6. Slightly disturbing
7. Moderately disturbing
8. Considerably disturbing
9. Extremely disturbing

Further questions elicited other noise sources, asked for a rating in a similar manner and also asked exactly what was annoying about the noise under consideration. These further questions will not be considered in the paper.

Interviewing was performed with approximately 10 persons for each of the 17 sites successfully monitored, making a total of approximately 170 interviews. Interviewing was also performed on weekends to ensure that the survey was not unduly biased towards housewives, men usually being at work during the week.

On analysis the 1 to 9 intensity scale judgements of train noise were split as follows:

1 to 5	Not annoyed
6 to 9	Annoyed

The percentage of people annoyed by trains was then calculated for each site. This technique was employed to give better correlations with measured noise levels by taking a coarser annoyed/not annoyed split rather than the fine 1 to 9 judgement actually asked for. The improvement in the correlation coefficients obtained using this technique was significant.

5. CORRELATION OF SOCIOLOGICAL RESULTS WITH NOISE DESCRIPTORS

The percentages of people annoyed by train noise (derived according to the previous section of this paper) were correlated with the statistical parameters obtained from the taped noise samples for the 17 sites. The correlation was performed at the Computing Centre at McMaster University, Hamilton using a Bio-Medical statistical package developed originally at the Health Sciences Computing Facility, UCLA, California. Typical correlation coefficients were obtained as follows:

Noise Level Descriptor	Correlation Coefficient	Significance Level
L_{90}	(0.21)	-
L_{50}	(0.15)	-
L_{10}	(0.16)	-
L_1	0.57	2%
$L_{0.1}$	0.72	0.1%
L_{eq} (total)	0.68	1%
L_{eq} (trains only, normalised to 24 hrs)	0.72	0.1%
$\log \frac{T}{24}$ (T=audible train duration hours)	0.69	1%

It can be seen from this table that the low level L values-L_{90}, L_{50} and L_{10}-do not have significant correlation with the percentage of people annoyed by trains. This is to be expected as the trains will not add into the cumulative statistical distribution at these levels. However, it may be thought that the higher the background noise levels then the lower the annoyance due to trains. This appears not to be the case as no significant negative correlation was obtained between the lower level statistical parameters and the percent of people annoyed.

Continuing towards the higher statistical parameters, $L_{0.1}$ shows very high correlation, significant at the 0.1% level. The total L_{eq} on the site (for all noise) correlates well with train noise annoyance but the L_{eq} for train noise alone normalized over 24 hours is slightly (but not significantly) higher. The logarithm of the fractional train noise duration also correlates well with train noise annoyance.

To further investigate the situation a multiplelinear regression analysis was performed using $L_{0.1}$ and $\log \frac{T}{24}$ as independant variables.

The regression line obtained had the equation

$$\text{Percentage annoyed} = -49 + 1.7\left[L_{0.1} + 10\log\frac{T}{24}\right] \quad (1)$$

with a corresponding correlation coefficient of 0.78 and a standard error of estimate of 17%. This regression line with the data points is shown plotted in Figure 1 together with the plus and minus one standard error of estimate lines. It is interesting to see that the $10\log\frac{T}{24}$ term in equation 1 is an energy type level/time trade off relationship thus supporting the applicability of L_{eq} for train noise assessment. Schultz (7) suggests a very similar rating scale of $L_{peak} + 10\log\frac{T}{24}$.

For completeness a single regression analysis was performed with the train noise L_{eq} normalized to a 24 hour duration as independant variable. The regression line obtained had the equation-

$$\text{Percentage annoyed} = -22 + 1.5\,L_{eq} \quad (2)$$

the correlation coefficient being again 0.72 and the standard error of estimate 18%. This regression line is also shown along with the data points and plus and minus one standard error of estimate lines in Figure 2. As the correlation coefficients of L_{eq} and $\left[L_{0.1} + 10\log\frac{24}{T}\right]$ are not significantly different then either rating scale could be considered to be equally as appropriate for the assessment of train noise annoyance.

6. CONCLUSIONS

The percentage of people annoyed by trains (obtained from a sociological survey) was correlated against various statistical parameters of noise (obtained by noise monitoring and analysis) for 17 sites. Approximately ten people were interviewed per site and noise recordings were made to capture short duration intermittent and continuous events.

The best correlators with train noise annoyance were $L_{0.1}$, L_{eq} for trains only normalized to 24 hours and $\log\frac{T}{24}$ were T is the audible train duration in hours per 24 hours. A multiple regression analysis was formed using $L_{0.1}$ and $\log\frac{T}{24}$ as independant variables and the following regression line obtained:

$$\text{Percentage annoyed} = -49 + 1.7\left[L_{0.1} + 10\log\frac{T}{24}\right] \ (\pm 17) \quad (1)$$

The term $10 \log \frac{T}{24}$ indicates the applicability of an energy type time/level trade off relationship for train noise. The correlation coefficient obtained was 0.78, which is higher than that obtained for the train L_{eq}, but not significantly different The regression line for the train noise L_{eq}, (normalized over 24 hours) is as follows:

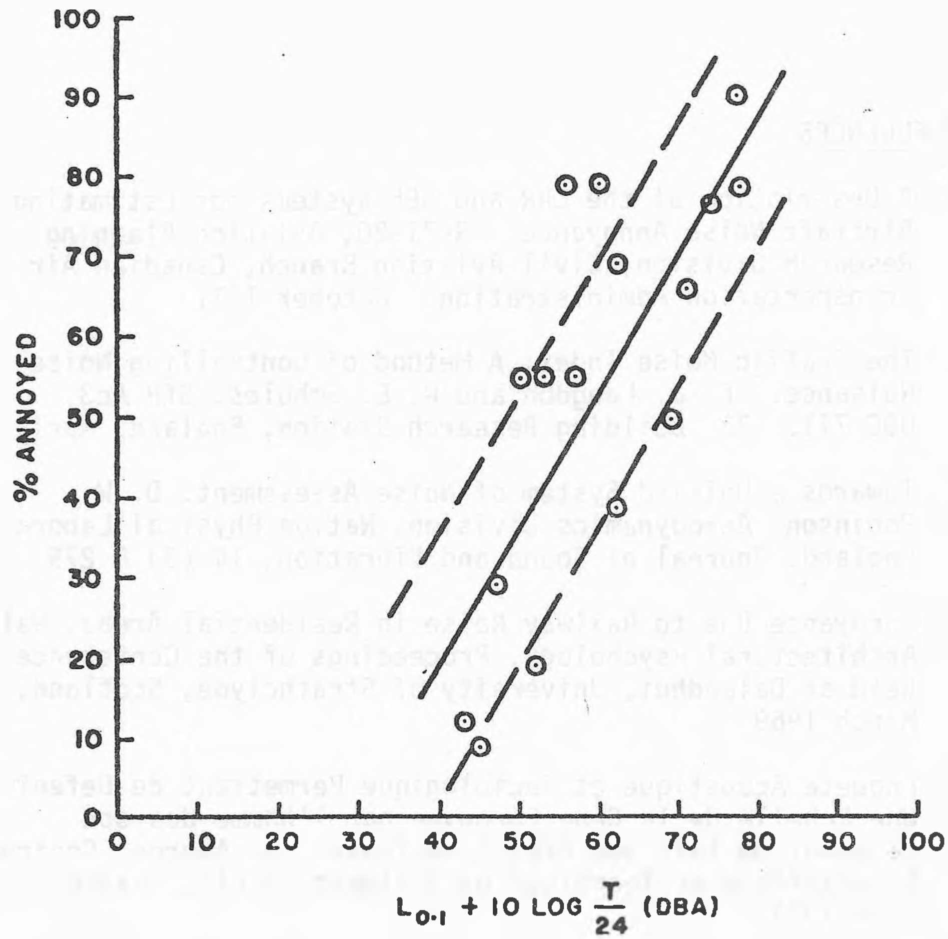
$$\text{Percentage annoyed} = -22 + 1.5\, L_{eq}\ (\pm 18) \qquad (2)$$

Either rating scale is considered equally applicable for the assessment of train noise annoyance.

The lower level statistical parameters L_{90}, L_{50}, L_{10} were found not to be significantly correlated with train noise annoyance At first sight this is an expected conclusion as the train noise is a short duration event. However, as no significant negative correlation was obtained it would appear that the background noise levels do not significantly affect the assessment of train noise annoyance.

ACKNOWLEDGEMENTS

The author would like to thank those members of the Noise Pollution Control Section, staff and students of Seneca College, Toronto and of McMaster University, Hamilton, who provided valuable assistance to this project.



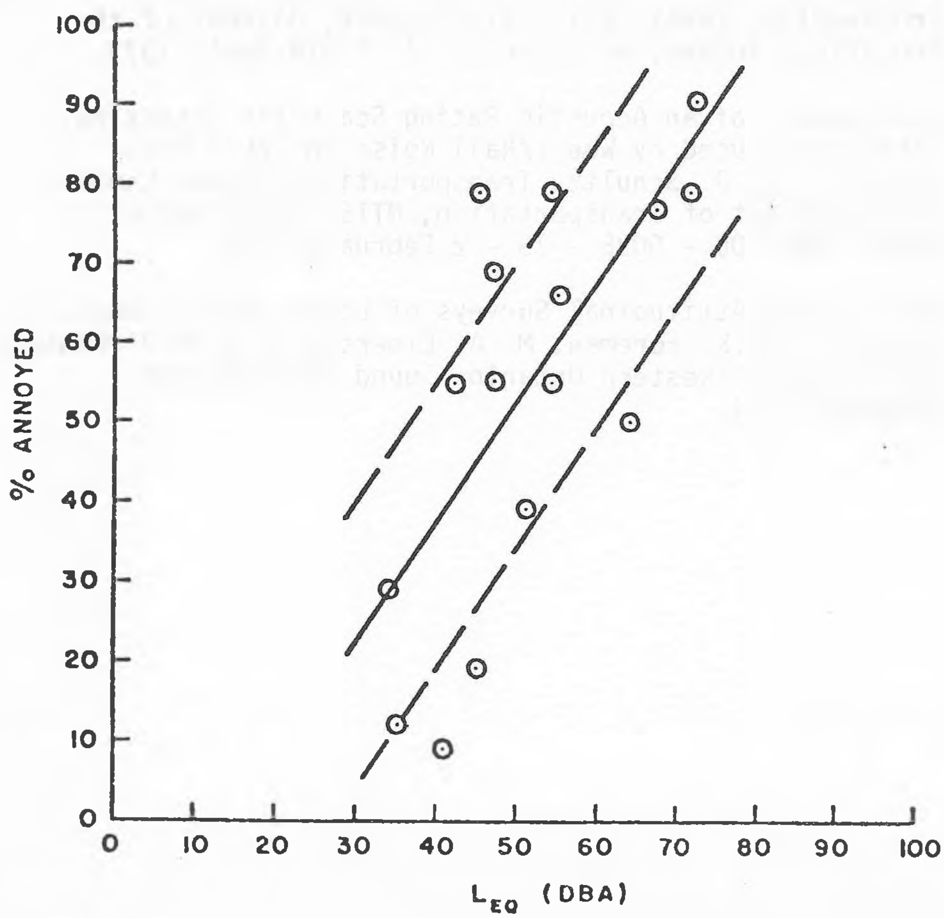


FIG 2

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DEVELOPMENT OF A MODEL FOR PREDICTING TRAIN PASS-BY NOISE PROFILES

J. R. Hemingway

Noise Pollution Control Section
Pollution Control Branch
Ministry of the Environment
Ontario

1. INTRODUCTION

Transportation represents the most significant community noise producer today. The three transportation sources - traffic, aircraft and trains - place considerable areas of land in a deteriorated noise environment and hence necessitate careful land use assessment to avoid inefficient or unsuitable development. In the major cities of Canada land is often at a premium, making efficient land use even more necessary.

Considerable effort has been brought to bear on prediction methods for aircraft and traffic noise. For aircraft noise in particular, sophisticated and detailed prediction methods exist (1). Traffic noise models have also been derived and are in general use (2,3,4). Although some work has been performed in the area of train noise prediction (5,6,7) it is not as considerable as that for aircraft or traffic.

The work which has been done is also made less applicable in Canada by several factors. Many models predict only the wheel-rail noise and have no prediction for locomotives. Many are concerned mainly with welded track and give widely varying corrections for the jointed rail in use in Canada and very few are concerned with prediction of the entire pass-by profile of the train.

Derivation of the complete pass-by is necessary for two reasons. First, noise control measures such as set-back, berms and double-glazing give different attenuations for the locomotive and wheel-rail noise because of differing source type, height and spectral content. To accurately predict the usefulness of noise control measures, the locomotive and wheel-rail signatures must be predicted separately. Secondly, for short trains (such as self propelled passenger trains or turbo-trains) the rise and decay of the noise profile as the train approaches and recedes can add significantly to the total noise exposure of the pass-by.

To fulfill these needs a semi-empirical train noise pass-by profile model was developed. The locomotive and wheel-rail noises were first considered theoretically as point and line sources respectively. Practical measurements in the field supplied the necessary level information of locomotive and wheel-rail noise for insertion into the theoretical model.

2. THEORY

The model of a passing train was taken to be as shown in Fig. 1. The observer track distance was taken as d. The train head - taken as being the locomotime, or first locomotive if several - passes the observer at time t=0 with velocity V. The locomotives are considered point sources located at the mid point of each and hence separated by one locomotive length. The rest of the train, the wheel-rail noise, is considered as a line source of length ℓ. Before the theory can be developed, consideration must be given to the directional characteristics of these sources. Peters (8) considered this problem and found the assumption of dipole radiation gave the best prediction of the rise and decay portions of the pass-by profile. Dipole radiation was assumed for both the locomotive and wheel-rail noise.

2.1 Locomotive Noise

The sound pressure, P_L (t) due to a locomotive of sound power W_L at the observer is given by

$$P_L^2 (t) = \frac{W_L \rho c}{2\pi} \cdot \frac{\cos^n\theta}{y^2}$$

where ρc = the characteristic acoustic impedance of air
y is the locomotive observer distance
and θ is as shown in Fig. 2.

The term $\cos^n\theta$ describes the directivity pattern of the radiation as described by Meakawa (9) for a dipole source. It was found from the practical measurements described in section 3 of this paper that n=l gave the best agreement with measured pass-by profiles giving

$$P_L^2 (t) = \frac{W_L \rho c}{2\pi} \cdot \frac{\cos\theta}{y^2} \tag{1}$$

or

$$P_L^2 (t) = \frac{W_L \rho c}{2\pi} \cdot \frac{d}{\{d^2 + (vt)^2\}^{\frac{3}{2}}} \tag{2}$$

Practical measurements were taken of train pass-bys at a distance of 50 feet to give the maximum locomotive sound pressure P_L. For these measurements

$$P_L^2 = \frac{W_L \rho c}{2\pi} \cdot \frac{1}{50^2} \tag{4}$$

Thus

$$P_L^2 (t) = P_L^2 \cdot \left(\frac{50}{d}\right)^2 \cdot \frac{1}{\{1 + (\frac{vt}{d})^2\}^{\frac{3}{2}}} \tag{5}$$

Or, finally converting to dBA levels.

$$L_L(t) = L_L + 20 \log_{10} \frac{50}{d} - 15 \log_{10} \{1 + (\frac{vt}{d})^2\} \quad (6)$$

Where $L_L(t)$ is the dBA level due to the locomotive at time t and L_L is the maximum dBA level measured at a distance of 50 feet.

2.2 Wheel-Rail Noise

The wheel-rail noise is considered to be a line source as shown in Fig. 3. The sound power at the observer due to a small element dx of the train is integrated over the length of the train (ℓ) to give the total sound pressure $P_W(t)$. The wheel-rail noise is assumed to have sound power W_W per unit length, $P_W(t)$ being given by:

$$P_W^2(t) = \int_0^{\ell} \frac{W_W \rho c}{2\pi} \cdot \frac{\cos^n \theta}{y^2} \cdot dx \quad (7)$$

Again the $\cos^n\theta$ term describes the directivity pattern of the radiation. For the wheel-rail noise, practical measurements (described in section 3) indicated that n=1 also gives the best agreement with pass-by profiles giving

$$P_W^2(t) = \frac{W_W \rho c}{2\pi} \int_0^{\ell} \frac{\cos \theta}{y^2} dx \quad (8)$$

or $$P_W^2(t) = \frac{W_W \rho c}{2\pi} \int_0^{\ell} \frac{d}{\{d^2 + (vt-\ell+x)^2\}^{\frac{3}{2}}} \cdot dx \quad (9)$$

which when integrated gives

$$P_W^2(t) = \frac{W_W \rho c}{2\pi} \cdot \frac{1}{d} \left[\frac{vt}{\{d^2 + (vt)^2\}^{\frac{1}{2}}} - \frac{vt-\ell}{\{d^2 + (vt-\ell)^2\}^{\frac{1}{2}}} \right] \quad (10)$$

Practical measurements of train pass-by taken at a distance of 50 feet to give the average wheel-rail sound pressure P_W. For these measurements

$vt = \ell/2$, d= 50 ft. and $\ell << d$ giving

$$P_W^2 = \frac{W_W \rho c}{2\pi} \cdot \frac{1}{50} \cdot 2 \quad (11)$$

Thus

$$P_W^2(t) = \frac{1}{2} P_W^2 \cdot \frac{50}{d} \left[\frac{vt}{\{d^2 + (vt)^2\}^{\frac{1}{2}}} - \frac{vt-\ell}{\{d^2 + (vt-\ell)^2\}^{\frac{1}{2}}} \right] \quad (12)$$

or, finally converting to dBA levels

$$L_W(t) = L_W + 10\log_{10}\frac{50}{d} + 10\log_{10}\left[\frac{vt}{\{d^2+(vt)^2\}^{1/2}} - \frac{vt-\ell}{\{d^2+(vt-\ell)^2\}^{1/2}}\right] - 3 \quad (13)$$

Inherent in equation 13 is the decrease in sound level with distance perpendicular to the track. When $d \lesssim \frac{1}{4}\ell$ than the final term is negligible and the sound level decreases 3 dB per doubling of distance. There then follows a transition region after which the two terms together produce a sound level decrease of 6 dB per doubling distance.

3. PRACTICAL MEASUREMENTS

3.1 Instrumentation

Sound from the train pass-by was detected by a B & K 2209 Impulse Precision Sound Level Meter fitted with a ½ inch Condenser Microphone. Amplified signals were fed to a Nagra Tape Recorder and recorded at 3 3/4 i.p.s. Recordings were made unweighted i.e. on "Linear" if wind conditions permitted or with "A" weighting if not.

The recorded signals were played back through the B & K 2209 and 'A' weighted if recorded unweighted. Unaveraged signals from the 2209 were passed to a B & K 2305 Level Recorder where the pass-by profiles were drawn out on paper tape. Averaging was performed by the Level Recorder with the equivalent of "Fast" set.

Train speeds were measured with a digital reading radar unit.

3.2 Measurement Details

Measurements were made at four locations in the Toronto area at a distance of 50 feet from new and old track operated by both Canadian National Railways and Canadian Pacific Railways. Pass-bys of some 40 trains (passenger, GO, turbo and freight trains) were recorded over a range of speeds from 10 to 70 miles per hour. As well as a sound recording and speed assessment for each pass-by other information such as type of train, type of locomotive and number of cars was noted.

4. MEASUREMENT RESULTS

From the paper trace of each train pass-by the maximum locomotive level and the average wheel-rail level was obtained. As the method of handling these two types of level was different they will be considered separately.

4.1 Locomotive Levels

The levels from each locomotive pass-by were plotted against speed as shown in Fig. 4. It was realized that a lower limit existed for the locomotive levels at low speed. Fortunately several of the GO train pass-bys included idling locomotives at the rear of the train. From the level of these locomotives and the plotted levels it was concluded that below 20 m.p.h. this lower limit level is in force. A linear regression analysis was then performed of level against the logarithm of speed for all constant speed locomotives travelling at more than 20 m.p.h. A correlation coefficient of 0.82 was obtained with a standard deviation of ± 2.4 dBA.

As it was felt that the locomotive level was also a function of the loading of the locomotive, the errors between each locomotive level and the regression line were plotted against the number of cars per locomotive in the train as shown in Fig. 5. A regression analysis was performed on these results, a correlation coefficient of 0.59 (significant at the 1% level) and a standard deviation of 2.6 dBA was obtained. The regression line plus and minus one standard deviation is shown in Fig. 5. At zero loading the regression line gave a correction of -3 dBA. The regression line of locomotive level against speed was lowered by 3 dBA to give an unloaded regression line. This is shown with plus and minus one standard deviation on Fig. 4. The results of the locomotive level analysis can be summarized as follows:

for idling, coasting or decelerating locomotives

$$L_L = 83.6(\pm 2.4) \text{ dBA} \tag{14}$$

for constant speed locomotives at less than 20 m.p.h.

$$L_L = 83.6\ (\pm 2.4) + 0.15\ N\ (\pm 2.6) \tag{15}$$

where N is the number of cars per locomotive

for constant speed locomotives at greater than 20 m.p.h.

$$L_L = 94.8 + 23.5 \log \frac{V}{60}\ (\pm 2.4) + 0.15N\ (\pm 2.6) \tag{16}$$

Also plotted on Fig. 4 are some points for accelerating or up-grade locomotives. It was judged that 3 dBA should be added to the above levels for locomotives which are either accelerating or going up-grade.

Fig. 6 shows a comparison of equation (15) and (16) with data from another source (10). In the cases where locomotives from ref. (10) were loaded, a loading correction was applied. Fair agreement is shown.

4.2 Wheel Rail Levels

Analysis of the wheel rail levels was more straight forward that the locomotive levels, a single regression analysis was preformed of level against the logarithm of the speed. A correlation coefficient of 0.82 was obtained with a standard deviation of 3.5 dBA. The individual points along with the regression line and the plus and minus one standard deviation lines are shown in Fig. 7. The results for the wheel rail noise is as follows:

$$L_W = 87.8 + 25.7 \log_{10}\left(\frac{V}{60}\right)\ (\pm 3.5) \text{ dBA} \tag{17}$$

Fig. 8 shows a comparison of equation (17) with data from other sources (5,6,11,12). Again reasonable agreement is obtained.

4.3 Prediction of the number of locomotive per train

As it is not always known how many locomotives will be pulling a certain train some method of predicting this is required. Fig. 9 shows a plot of the number of locomotives pulling a train against the total number of cars. From these results it was thought that the approximation shown on Fig. 9 gave a reasonable prediction of the number of locomotives, as follows:

0 to 35 cars	1 locomotive
35 to 70 cars	2 locomotives
70 to 105 cars	3 locomotives
105 to 140 cars	4 locomotives

etc.

5. CONCLUSIONS

A semi-empirical train pass-by noise profile model has been developed which is able to predict locomotive levels, wheel rail levels, level rise and fall as the train approaches and recedes and level decrease with distance. It is felt that the level decrease with distance as predicted could be a weak point in the method as practical measurements were only taken at a single distance relative to the track. It has been noted (5) that divergencies can occur from the classical 3 dB and 6 dB per double distance decrements. This is probably due more to varying ground cover rather than model errors but is a problem which requires further investigation.

ACKNOWLEDGEMENTS

The author would like to thank those members of the Noise Pollution Control Section who provided valuable assistance to this project. The work of Jorgen Madsen, a summer student from Denmark is also gratefully acknowledged.

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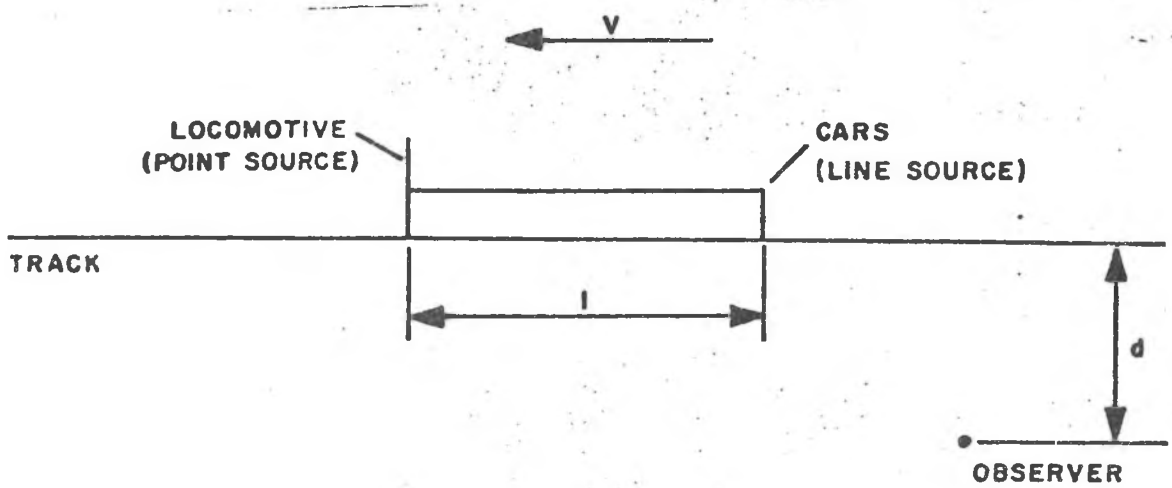
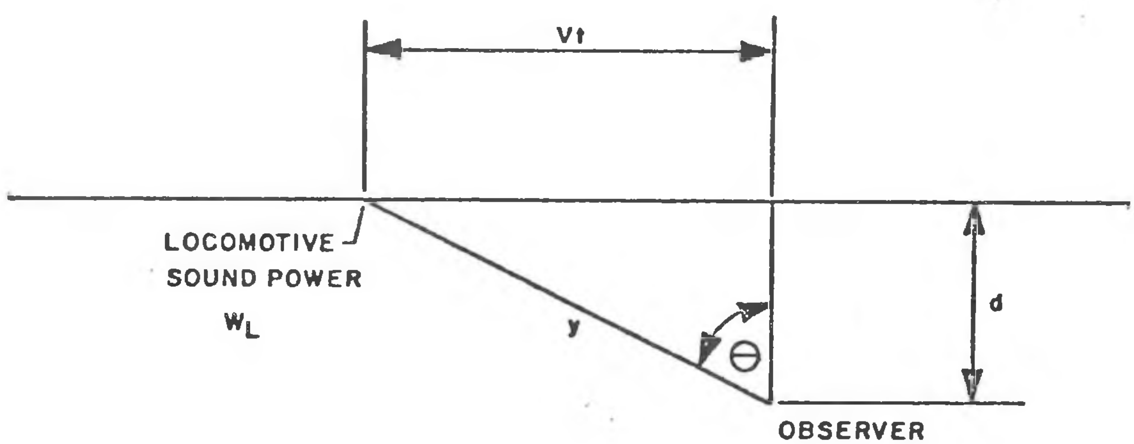

V
LOCOMOTIVE
(POINT SOURCE)
CARS
(LINE SOURCE)
TRACK
l
d
OBSERVER

FIG 1


Vt
LOCOMOTIVE
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W_L
y
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OBSERVER

FIG 2

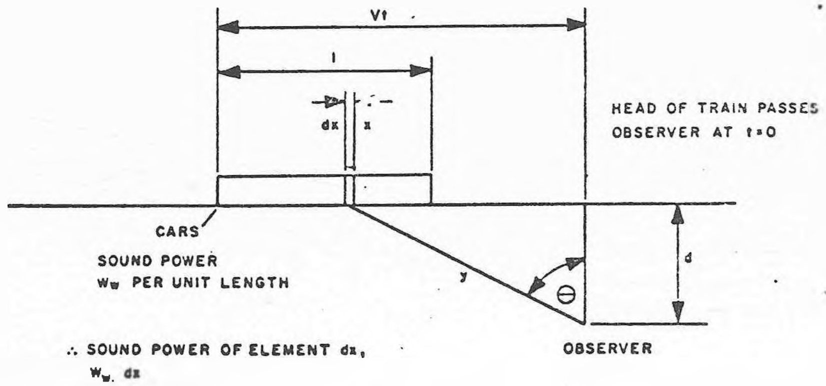
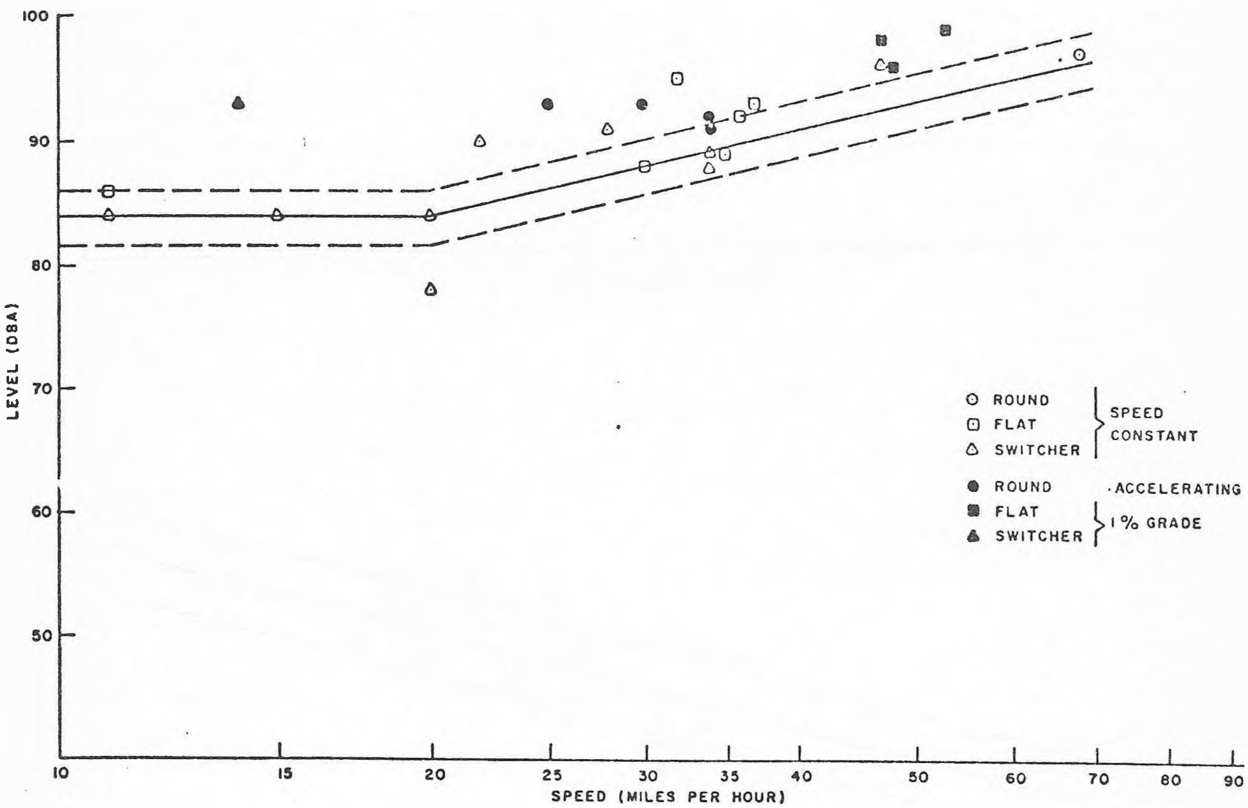
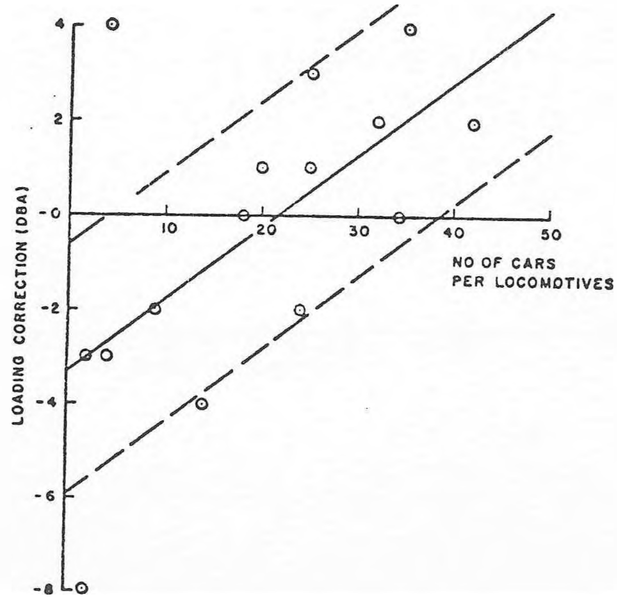
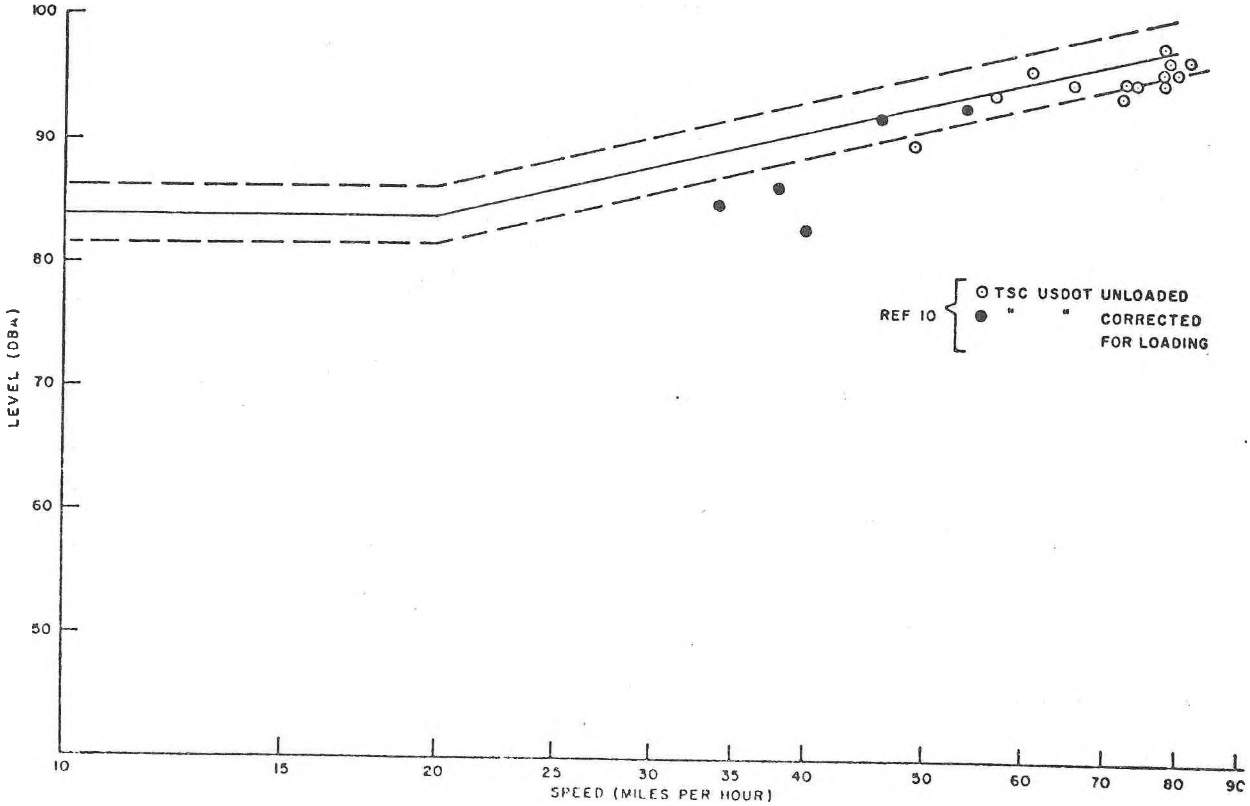
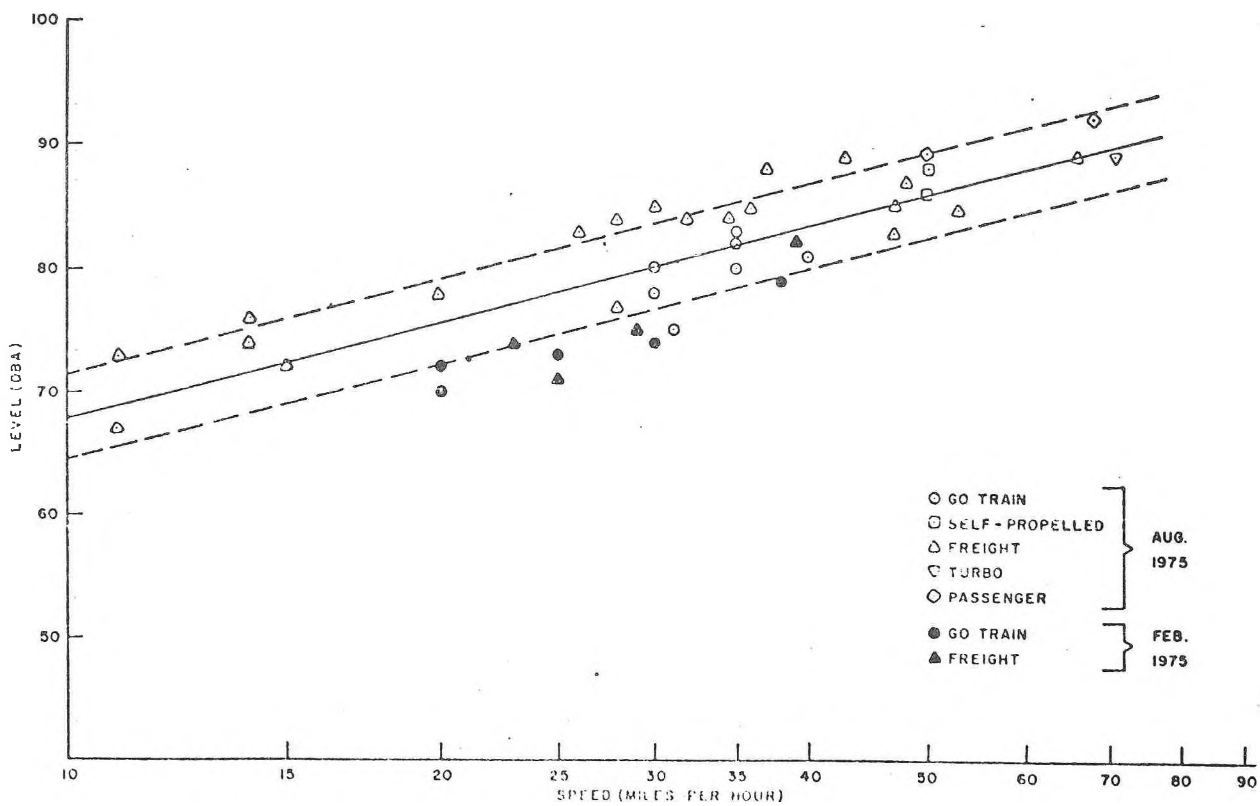

Vt
l
dx
x
HEAD OF TRAIN PASSES
OBSERVER AT t=0
CARS
SOUND POWER
W_w PER UNIT LENGTH
y
d
OBSERVER
∴ SOUND POWER OF ELEMENT dx,
W_w. dx

FIG 3


100
90
80
70
60
50
LEVEL (DBA)
10
15
20
25
30
35
40
50
60
70
80
90
SPEED (MILES PER HOUR)
ROUND
FLAT
SWITCHER
SPEED
CONSTANT
ROUND
FLAT
SWITCHER
ACCELERATING
1 % GRADE


4
2
0
-2
-4
-6
-8
LOADING CORRECTION (DBA)
10
20
30
40
50
NO OF CARS
PER LOCOMOTIVES


100
90
80
70
60
50
LEVEL (DBA)
10
15
20
25
30
35
40
50
60
70
80
90
SPEED (MILES PER HOUR)
REF 10
TSC USDOT UNLOADED
" " CORRECTED FOR LOADING


100
90
80
70
60
50
LEVEL (DBA)
10
15
20
25
30
35
40
50
60
70
80
90
SPEED (MILES PER HOUR)
GO TRAIN
SELF-PROPELLED
FREIGHT
TURBO
PASSENGER
AUG. 1975
GO TRAIN
FREIGHT
FEB. 1975

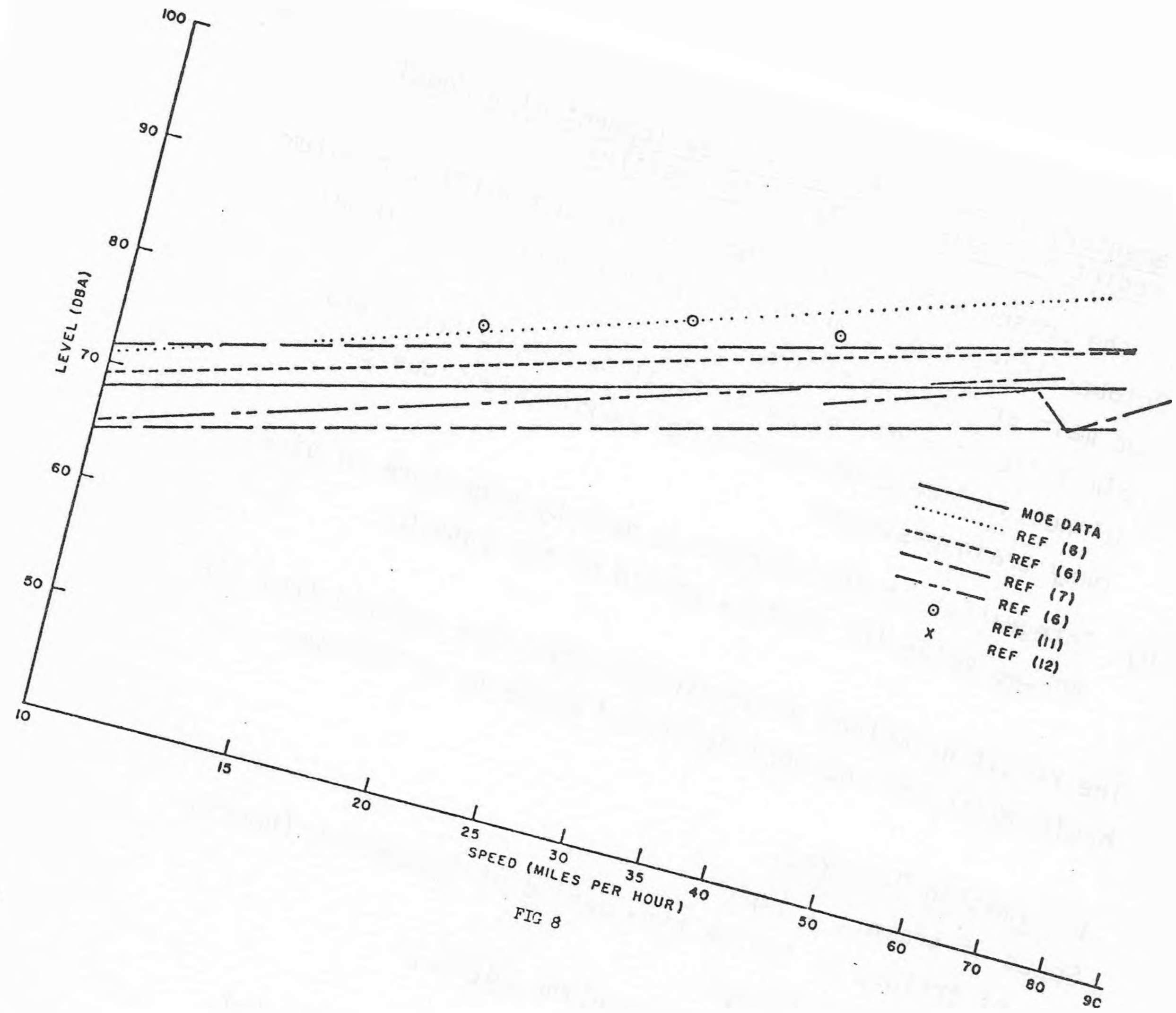

LEVEL (DBA)
100
90
80
70
60
50
10
15
20
25
30
35
40
50
60
70
80
90
SPEED (MILES PER HOUR)
MOE DATA
REF (8)
REF (6)
REF (7)
REF (6)
REF (11)
REF (12)

FIG 8

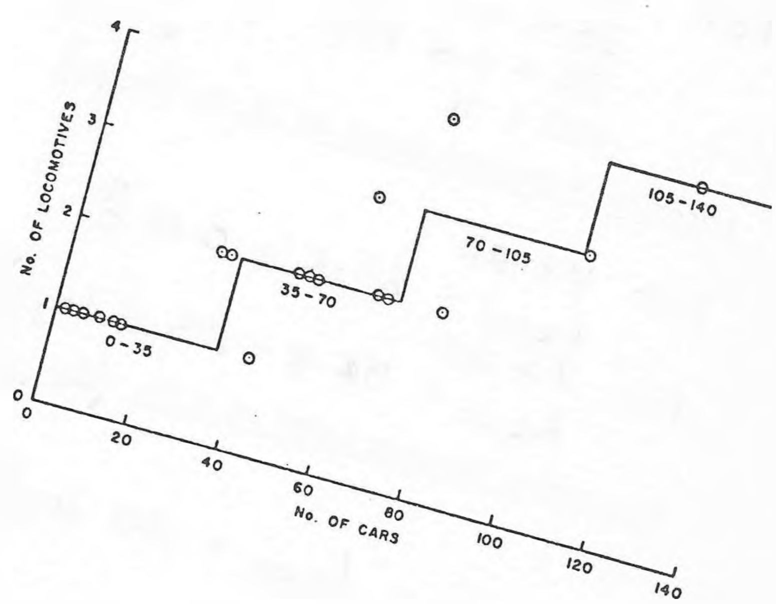

No. OF LOCOMOTIVES
0
1
2
3
4
0-35
35-70
70-105
105-140
0
20
40
60
80
100
120
140
No. OF CARS

FIG 9

Supplementary Notes to the Paper "Development of a Model For Predicting Train Pass-by Noise Profiles"

Since the presentation of the above paper to the CAA Symposium in October 1975, I have performed further work on the model in two main areas. These are:

a) Simplification of the model to allow simple prediction of noise climate on residential subdivisions due to many train pass-bys.

b) Integration of the locomotive pass-by signature to give an L_{eq} value for thetime period of the pass-by.

The resulting method of prediction which has evolved from the basic model and the work described above is as follows:

Information Required:

Speed of trains, V (mph)

No. of trains, N. in the time period of interest H (hours)

No. of cars per train, n

Distance from the track centreline, d(ft.)

Estimation of the Number of locomotives per train (e)

for $0 < n < 35$, $e = 1$

$35 < n < 70$, $e = 2$

$70 < n < 105$, $e = 3$

$105 < n$, $e = 4$

Locomotive Maximum Level at 50 ft. ($L_{L,50}$)

for $V < 20$

$$L_{L,50} = 83.6 + 0.15\frac{n}{e} \quad \text{(dBA)}$$

for $V > 20$

$$L_{L,50} = 94.8 + 23.5\log\frac{V}{60} + 0.15\frac{n}{e} \quad \text{(dBA)}$$

Locomotive Maximum Level at d ft. ($L_{L,d}$)

$$L_{L,d} = L_{L,50} + 20\log\left(\frac{50}{d}\right) \quad \text{(dBA)}$$

Locomotive Leq at d ft. ($L_{EQ,L}$)

$$L_{EQ.L} = L_{L,d} + 10\log\left(\frac{d}{55}\right) + 3 \quad \text{(dBA)}$$

(L_{eq}, L turns out to be higher than expected as the time of the pass-by will be taken as the time for which the locomotive is in front of the observer. 55 ft. is a representative length for a locomotive.

Locomotive Time (T_L)

$$T_L = e \cdot N \cdot \frac{55}{V} \cdot \frac{15}{22} \qquad \text{(seconds)}$$

Wheel/Rail Level at 50 ft. (L_W,50)

$$L_{W,50} = 87.8 + 25.7 \log \frac{V}{60} \qquad \text{(dBA)}$$

Wheel/Rail Leq at d ft. ($L_{EQ,W}$)

$$L_{EQ,W} = L_{W,50} + 10 \log \frac{50}{d} - 5 \log\left\{1 + 4\left(\frac{d}{57n}\right)^2\right\}$$

(the final term will be negligable if $d < \frac{1}{4} \cdot 57n$)

Wheel/Rail Time (T_W)

$$T_W = n \cdot N \cdot \frac{57}{V} \cdot \frac{15}{22} \qquad \text{(seconds)}$$

(57 ft. is a representative length of each car)

Total Leq over time period H hours

$$L_{EQ} = 10 \log \frac{1}{H.3600}\left\{10^{0.1 L_{EQ,L}} \cdot T_L + 10^{0.1 L_{EQ,W}} \cdot T_W\right\}$$

J.R. Hemingway

J. R. Hemingway, P. Eng.
Senior Project Engineer,
Abatement and Assessment Unit,
Noise Pollution Control Section
Ministry of the Environment

An Investigation of Railroad Car Retarder Squeal

M.G. Faulkner and A. Mioduchowski
Associate Professors
Dept. of Mechanical Engineering
University of Alberta
Edmonton, Alberta. T6G 2G8

1. Introduction

While the use of humpyards for the classification of railroad cars has been very effective in increasing the volume of cars handled in a yard, one unpleasant by-product of this system is the squeal which is often generated by the retarder systems. As the cars roll down an incline (the "hump") they are slowed by means of a retarder system which usually is two braking mechanisms. These clamp onto the wheels of the car as it passes. The initial retarder, called the master, begins to slow the cars while the second is one of the group retarders. Figure 1 shows three of the group retarders as well as the classification tracks at the CNR Calder Yard in Edmonton. For certain cars (usually the heavier ones) the retarder brake acting on the car wheels causes a high pitched squeal to be generated. The retarders must dissipate energy at rates of up to 400 kW (>500 HP) and even if a relatively small amount is converted to acoustic power high sound pressure levels can result.

Levels of approximately 120dB have been recorded at distances of 100 feet from the retarder. Since most of the acoustic energy is in the 2000-4000 Hz range the squeal tends to be very annoying. Because of the relatively high frequency of the squeal the use of barriers to control the noise seems an obvious answer. While barriers as low as six feet in height have been shown to be effective the practical limit to the insertion loss is about 25 dB. However, this is not sufficient as areas surrounding the retarders can still be severely impacted by the squeals. For this reason alternate techniques which would reduce the noise further have and are being sought.

2. Noise Generation Mechanisms

In order to consider the possible methods for reducing the noise the mechanism which causes the squeal should be understood. While the detailed mechanism for the retarder - wheel system is not known it is believed to be stick-slip vibration or friction induced vibration such as that studied for example by Brockley, Cameron, and Potter [1] and Remington, Rudd and Ver [2].

The screech noise is excited by friction forces that act between the retarder shoes and the car wheels. When these two surfaces have relative sliding motion, intermittent vibration which can be attributed to the variation of the friction forces is observed. For dry friction the motion is a self-excited phenomenon. This occurs because the static coefficient of friction is larger than kinetic coefficient. While the kinetic coefficient is a function of time or the relative velocity between the two surfaces it must in fact be lower than the static value if stick-slip vibrations are to occur. Once establishing the velocity and time dependence of friction, it is possible to obtain an analytical solution to the critical velocity which will cause this stick-slip oscillation.

The analysis also shows that increasing the damping of the system or altering the friction-velocity characteristic can reduce or eliminate the stick-slip action.

The above analysis would account only for radial type oscillations of the car wheel, however, because of the complex shape of the car wheel the transverse modes are also excited. It is these transverse modes which are held primarily responsible for the generation of the acoustic waves which propagates as the screech.

3. Methods of Controlling the Noise

The techniques used to control or eliminate the retarder shoe squeal include path-type controls such as barriers, which have been mentioned above, as well as modification of the source elements.

One of the easiest and quickest techniques to eliminate the screech was the use of various lubricants between the wheel and retarder shoe. These lubricants had the effect of reducing the differences between the static and kinetic coefficients of friction and proved quite effective in the elimination of the squeal. They did, however, reduce the effectiveness of the retarders and in many cases caused cars to "slip through" which could lead to disasterous consequences.

Another method of modifying the friction forces between the wheel and retarder shoe is to modify the metals in contact. The first metal used for the retarder shoes in place of steel was ASTM 60 ductile iron. While the incidence of squeal was reduced using the ductile iron the sound intensity was similar once the squeal began. As well these shoes wore at approximately four times the rate of steel shoes. Other types of shoes for example those containing nodules of graphite are being tested. These type of shoes have shown improvements as far as reducing the squeals, however, the life of these shoes is considerably less than those of the usual carbon steel ones.

As mentioned above the addition of damping to the stick-slip system could theoretically eliminate the stick-slip action. For this reason damping of both the retarder beams and the car wheels has been attempted. The retarder beams were damped by adding sand bags and loose sand to the top of the retarder beam. This produced no noticeable change in screech level. The car wheels have been damped by attaching a sheet of viscoelastic damping material to the wheels as well as by applying wooden damping shoes which were pressed against the wheels during the time in which the wheel is being braked. The wooden damping shoes had no effect whatever on the wheel screech while the viscoelastic damping did have some positive effect. While the addition of this damping material may be effective the idea of installing it on the thousands of railroad cars in North America makes it an unworkable solution.

More complicated techniques have also been tried. These include modulating the pressure applied to the retarder shoes so that the screech does not "build-up" and the modification of the retarder beam to alter its mass-stiffness characteristic. Neither of these ideas has shown much promise.

4. Current Investigation

One of the humpyards with squeal problems is the CN Calder Yards in Edmonton. This facility has an enclosure built over the master retarder to control the noise, however, the four group retarders have only partial barriers to reduce the transmission of the high frequency squeal from the retarder-car wheel interaction (see Figure 1). In considering possible solutions to the squeal preliminary investigations of the nature of the noise and vibration from this facility were undertaken. The vibration of the retarder beam as well as the squeal produced were monitored simultaneously. A closeup of the retarder beam is shown in Figure 2 while the system used to monitor the noise and vibration is shown in Figure 3.

The recordings were taken on May 13, 1976 while a group of ten cars were humped 5 consecutive times. These cars were all relatively heavy and all of them squealed excessively.

Recordings were taken for vibration in the longitudinal direction (i.e. parallel to the track) and in the vertical direction. Recordings were also taken in the horizontal but perpendicular to the track. As well the natural vibrations which occurred when the track was impacted in the longitudinal direction were also recorded.

The recordings were later analyzed on a Hewlett Packard 3721A Correlator and displayed on a 3720A Spectrum display and finally plotted on a Hewlett Packard 7044A X-Y Plotter.

Examples of the spectrum analysis are shown in Figure 4 where the results for 3 different cars during the first hump are shown. These results as well as similar ones for other cars and other hump numbers show a very strong correlation between the vibrations of the retarder (measured in the longitudinal and vertical directions) and the noise produced. They also indicate that in most cases a large amount of the energy lies in the 2600-2800 Hz frequency range and not in a wide band of frequencies. Coupled with the fact that one of the natural modes of vibration (in the longitudinal direction) is in the 3000 Hz range leads one to believe that the most critical frequency range is the 2600-2800 Hz band. While the magnitudes of the vibration both above and below this range were sometimes substantial the 2600-2800 Hz band was most often the major contributor to the overall acoustic energy.

5. Possible Solutions

While the investigation to date has not uncovered all apsects of the noise generation mechanism the results obtained point to some possible techniques for controlling the noise.

There are many reasons to believe that the wheel and not the retarder beam is the primary resonant system and therefore responsible for the majority of the noise created. For this reason noise control measures which reduce wheel vibration would appear to be most successful. However, the treating of all railroad car wheels appears to be economically unattractive and one is therefore led to consider the retarder. The fact that there is a strong correlation between the vibration of the retarder and the noise generated leads to the conclusion that there is a strong coupling between the wheel and the retarder. It follows that reducing the retarder vibration will in turn reduce the noise generated.

Previous attempts (mentioned above) at damping the retarder beam by such means as sand bags were unsuccessful. However, the possibility of absorbing the retarder vibration by means of a dynamic vibration absorber [3] could be more effective. This is especially true since the frequency which tends to be the most bothersome is in a fairly narrow band of frequencies (2600-2800 Hz). In this range a vibration absorber should be able to be quite effective in nearly eliminating the retarder vibration. Should the absorber vibration itself cause a squeal it could be readily housed and the noise easily absorbed. It is planned to design and test such a dynamic vibration absorber system in the future.

References

[1] C.A. Brockley, R. Cameron and A.F. Potter, "Friction Induced Vibration", Journal of Lubrication Technology, Vol. 89, pp. 101-108, (1967).

[2] P.J. Remington, M.J. Rudd and I.L. Ver, Wheel/Rail Noise and Vibration Volume I: Mechanics of Wheel/Rail Noise Generation, Urban Mass Transportation Administration Report No. UMTA-MA-06-0025-75-10 (1975).

[3] W.T. Thomson, Theory of Vibrations with Applications, Prentice Hall (1972).

Acknowledgements

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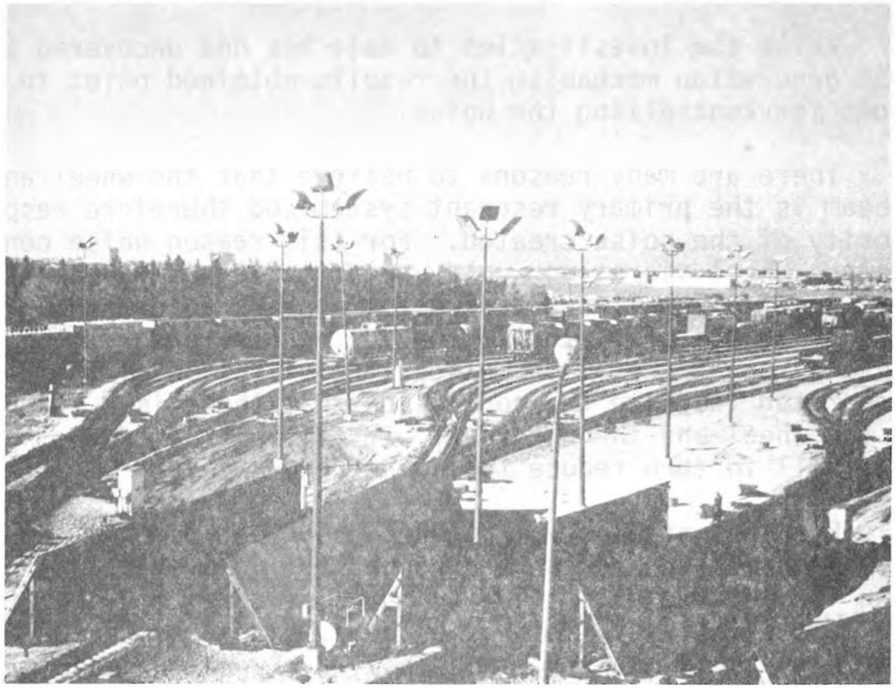


Figure 1

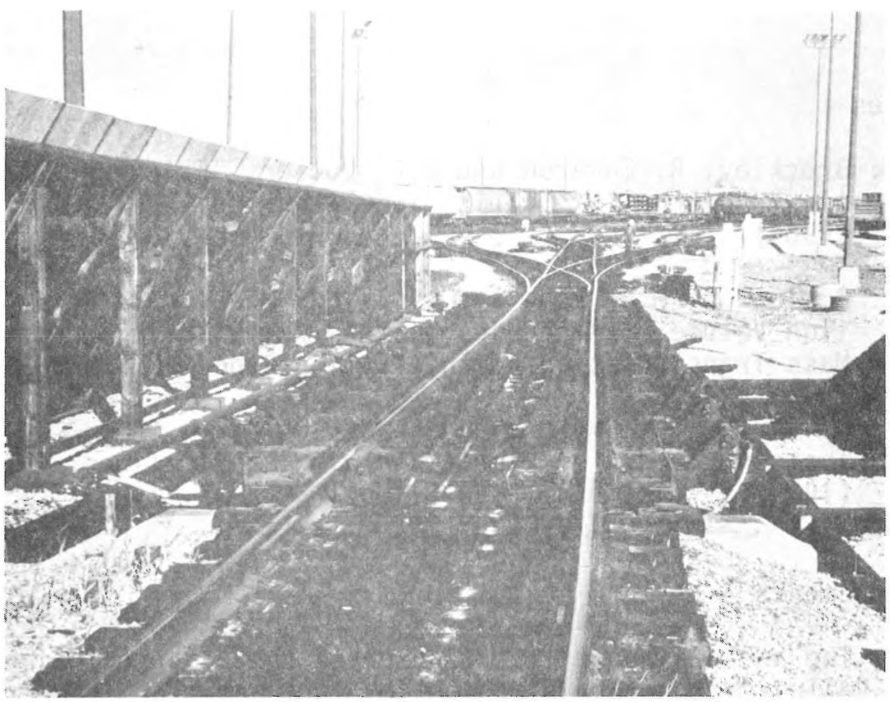
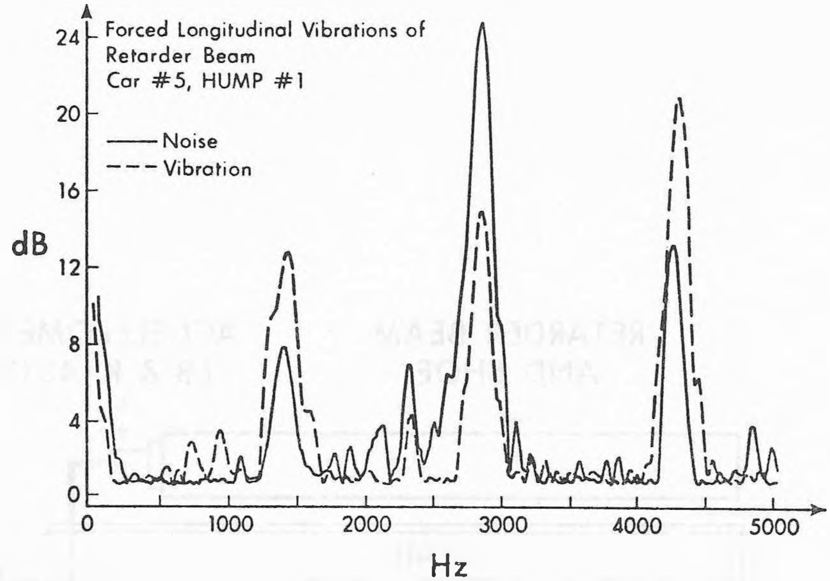
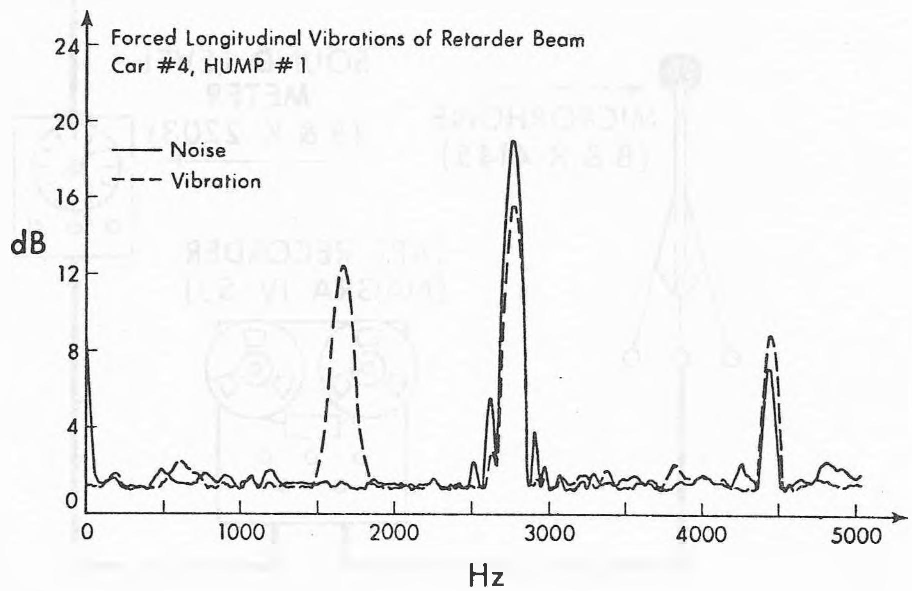


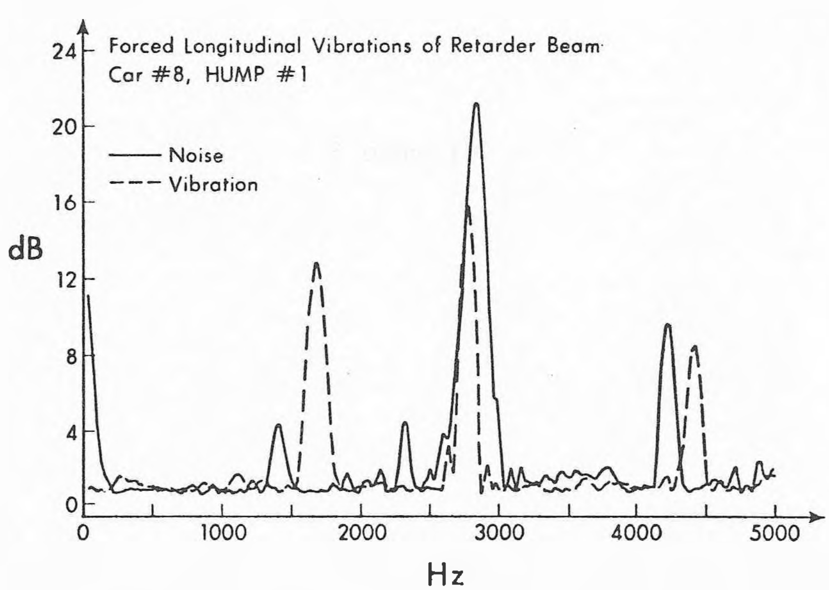
Figure 2


Forced Longitudinal Vibrations of Retarder Beam
Car #5, HUMP #1
Noise
Vibration
dB
Hz

(a)


Forced Longitudinal Vibrations of Retarder Beam
Car #4, HUMP #1
Noise
Vibration
dB
Hz

(b)


Forced Longitudinal Vibrations of Retarder Beam
Car #8, HUMP #1
Noise
Vibration
dB
Hz

(c)

Figure 4

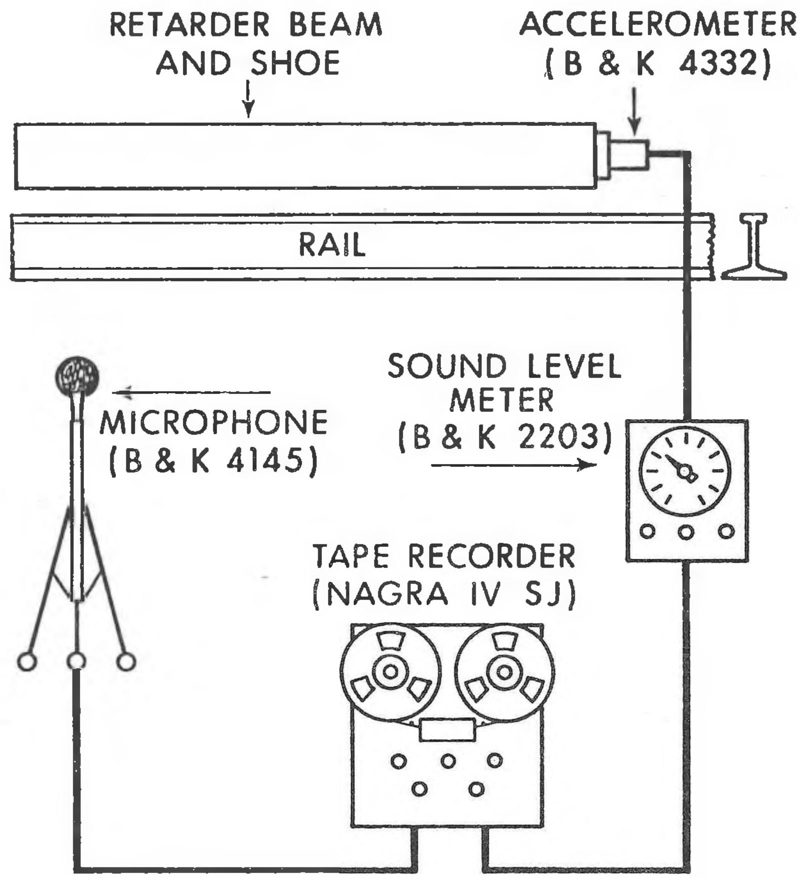

RETARDER BEAM
AND SHOE
ACCELEROMETER
(B & K 4332)
RAIL
SOUND LEVEL
METER
(B & K 2203)
MICROPHONE
(B & K 4145)
TAPE RECORDER
(NAGRA IV SJ)

Figure 3